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Architects' View of Concurrent Engineering in Construction Projects

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ABSTRACT

The size of the projects in the construction sector necessitates faster execution of works and at the same time to remain within budget. In a timely and cost-effective completion of a construction project has always been the subject of research. In this regard, the concept of concurrent engineering that has been used in various sectors is considered and adapted in the construction industry. An architect is usually the first addressed person by the owner in a construction project. Architects undertake the design whilst considering the general features of the structure and the demands of the owner, and also want to be sure that the job is finished as intended eventually. In this context, the concept of concurrent engineering is overviewed firstly in this study. Concurrent engineering applications in the literature are reviewed. Accordingly, the matrix organization model for a construction project is provided. In addition, the situations faced by architects are examined through a survey. In the survey, 97 architects were interviewed. The perception of the concept of concurrent engineering and the related situations they face in their projects are evaluated. According to results, even implementation of some concepts of concurrent engineering may lead to the important gains, such as, the timely completion of project and likely avoidance from an increase in costs. Meanwhile, participation of the parties that are held throughout the project through meetings will ensure that the potential problems, such as plan change requests and the occurrence of changes without notification can be reduced. It is our hope that this study encourages to adapt concurrent engineering in a construction project by stakeholders.

Keywords: Schedule, Budget, Cross-Functional Teams, Owner Relations

1 INTRODUCTION

In this era of information and communication world, the competitive and changing environment in and out of enterprises led to new ideas, new technologies, new organizational structures, new strategies and new approaches about administration. At this point, Concurrent Engineering (CE) concept has emerged as a result of innovations in the product development process. This concept represents a management approach focused on improving four key conflicting factors, such as, quality, cost, time, and customer's demands in the product development process in a balanced way. CE brings together all the groups in the project as early as the design phase. CE ensures that all the requirements during design, construction, operation and maintenance phases of the project are dealt with from the conception and design stage while addressing quality, cost, time and customer's demands (Winner et.al. 1988; Cleetus 1992; Anumba et.al. 1997; Anumba et.al. 2000; Brookes and Backhouse 1998; Love et.al. 1998; Kamara et.al. 2000; Khalfan et.al. 2001a).

In literature, it was stated that improvements can be achieved in the company's management functions (planning, organization, coordination, command and control) and competitiveness can be increased by the implementation of CE in companies. Several authors stated that better planning of projects can be done with the implementation of this approach, thus reducing the time and cost of the project and also achieving the desired performance and quality construction output (Sanvido and Medeiros 1990; Anumba et. al. 1997; Crowley 1996; Egan 1998; Kamara, Anumba and Evbuomwan 2001). Ireland (1994) pointed out that 25% to 40% savings in time and money could be achieved in construction projects. There is an effective report written by Sir Michael Latham who was appointed by the British government in 1994 to review procurement and bidding regulations in construction industry. This Latham Report named "Setting up the Team" concluded that 30% savings in construction costs could be achieved by using the then new techniques such as CE (Khalfan et al. 2001). Evbuomwan and Anumba (1998) argued that the project cost and duration could be reduced as much as 30% by CE applications. Many authors also stated that up to 70% reduction in product development times could be accomplished by employing CE (Dowlatshahi 1992; Prasad 1996; Kamara et. al. 2001). Despite these positive aspects of the CE in the literature, some negative aspects of CE were also pointed out. For example, if the company may not be equipped to handle large-scale information concurrently (Prasad 1996). As a result of this, deterioration in the return period of information or congestion in information storage can occur which in turn may lead to increases in the cost and duration of the project.

In the literature, the significance of CE was examined over a wide range. Brookes and Brookes and Backhouse (1998) observed that various authors defined CE at tactical, strategic, and practical levels. These authors defined CE "tactical" when different tools and techniques used by the organization and the structure of the organization itself are considered; "strategic" if all phases of the product is considered in parallel; and "practical" if improvements toward the performance of the entire business is described. According to some researchers (such as, Meyer 1990; Shina 1991) the factors affecting CE are the parallel tasks, cross-functional teams, mutually interdisciplinary working groups, used quality techniques (QFD, SPC, Taguchi, DFM, DFA, etc.), and design techniques for integrated CAE and manufacturing. In contrast, Prasad (1996), discussed seven items (7T), such as, Talents, Tasks, Teams, Techniques, Technology, Time and Tools, effecting CE field. Prasad (1996) has also founded CE on 8 basic principles. These are; early discovery of the problem, understanding about early decision-making, systematic structuring of the work, the spirit of teamwork, use of information technologies, common understanding, a sense of ownership and perpetuity of purpose.

2. Perceptions about Concurrent Engineering (CE) in Construction Industry

Concurrent Engineering is used especially in the software and manufacturing sectors. Towards the implementation of this approach, there is growing interest in the construction industry. The main factor responsible for the development of this approach, as well as other industries is the necessity for the professionals to do their works in line with technological advancements and in cooperation with the other professionals.

2.1.1. Description of CE for construction industry

CE is a systematic and integrated product development approach in which design and production phases became optimal (Cleetus 1992; Anumba and Evbuomwan 1997; Evbuomwan and Anumba 1998; Khalfan et.al. 2001). In CE, all life-cycle perspectives within the product design, production, management, and operation processes are integrated according to customer requirements. These perspectives are considered as early as the conceptual phase by mutual and parallel works of all the professionals involved in the project. Project design and production durations and cost are reduced meanwhile project performance and quality are increased by reaching the final decisions via exchanging information.

2.1.2. Challenges about the implementation of CE in the construction industry

Some difficulties arise in the application of CE in the construction industry due to the specific conditions of the industry itself (Kamara et. al. 1997). These are:

- In the manufacturing sector, the same product can be produced more than once from the same design i.e., the mass production can be made. However, in the construction industry generally both design and production takes place only once.
- Construction works begin with an architectural concept design based on the information provided by customer to the architect. This design is then given to the civil engineer. After structural design is completed, the cost of the project will be calculated by estimator. In the meantime, electrical, mechanical and other plans are prepared by the related engineering project groups. When these works are completed, the project is transmitted to contractor who assumes the responsibility for the construction of the building. With the acceptance and delivery stages, the project process is completed. Therefore, in the development of construction projects, there are many participants representing different disciplines and areas of expertise, belonging to different occupations. Efficiently integrating the different methods and tools used in the performance of these participants' is not an easy task. This requires the separation of tasks carefully. Due to the high dependency between tasks, when a functional discipline has completed its task, that may lead to the creation of metaphorical "walls" over which the project has to be crossed between disciplines. This "wall" prevents each discipline to communicate with each other effectively. This "over the wall" approach in the construction industry toward the project development results many shortcomings, such as; (i) not accurately specifying customer needs; (ii) not to be able to reach information produced at the design and construction phases later on; (iii) emergence of errors and misunderstandings; (iv) changes in design because of incomplete and inadequate design specifications; and (v) rising of the cost and duration of design (Anumba et.al. 1997; Evbuomwan and Anumba 1998; Anumba et. al. 2002).
- One of the major factors for the implementation of CE is the information sharing and a high level of cooperation between the multi-functional teams. When it comes to construction industry, organizational barriers may occur especially in the field of information sharing.
- Separation of design phase from the construction phase makes that the contractors and suppliers are to be included efficiently in the design team almost impossible. However, in application of CE approach for many companies, the main problem is that the approach brings with it a serious organizational and technological change about the structure of the company. Before starting CE practice, the removal of barriers in this direction is required. There are usually two types of barrier about the implementation of CE in the company:
- *Technical barriers:* These barriers include a lack of communication system, the lack of a common database, CAD / CAM system, the absence of knowing exactly how to use the software and hardware, and directing acceptably EDM / PDM data management systems.
- *Organizational Barriers:* These barriers include the lack of senior management support and the lack of involvement of the customer and the supplier. Also, the organizational structures that do not support the rewarding systems and that promote protective functional divisions and that is based on the individual objectives can also constitute such barriers (Parsaei and Sullivan 1993; Anumba et. al. 2002).

2.2. CE framework

To understand the concept of CE, CE framework or in other words, the relationships between objectives, goals, strategies, tools, and techniques of CE is needed to be determined (Brookes and Backhouse 1998; Anumba et. al. 2002; Kamara et. al. 2000). Deasley and Lettice (1997) studied the process of enforcing and sustaining CE in twenty production companies. In their study, the process was grouped as (i) preparation, (ii) team-based integrated product development, (iii) the management of multi-disciplinary teams and organization and (iv) keeping the feedback data to be used in organizational management and development of processes. In this way, the authors, in a way, drew the framework of concurrent engineering.

2.2.1. Preparation

This stage is a one that aids the organization to understand and absorb the changes required by CE. The preparation phase should usually be considered as an important phase of the commitment creating process for the firm. At this stage, there should be activities that determine the success of upcoming stages. Preparation assessment study helps to identify critical risks related to CE implementation and to investigate the extent of readiness of the organization to implement CE (Componation and Byrd 1996; Khalfan, Anumba and Carillo 2001a). For this purpose, by various authors, "preparation assessment tools and models" have been developed and used in order to evaluate usually the product development process. Khalfan Anumba, Carillo (2001c) developed models about the readiness of a company for the implementation of CE and identification of the potential problem areas in the process. With this and other models later developed; the readiness for concurrent engineering of the participating contender firms which consider about making the transition to the CE is measured. To do this, a variety of features of each model are collected under the headings of the survey conducted with company representatives. The result is obtained as a score on the current state of the company specified on the result of the survey. Then, as a result of the evaluation of scoring, the extent of company readiness for CE and potential problem areas are determined. The authors determined that the most appropriate preparedness assessment model to be used in the construction industry in this direction was "RACE model" (the Readiness Assessment for Concurrent Engineering) developed by CERC in 1993. Based on RACE model, firstly "CERAMConstruct", and then after some revisions on the "CERAMConstruct", BEACON (Benchmarking and Readiness Assessment for Concurrent Engineering in Construction) models have been developed. Particularly using CERAMConstruct model in the construction industry, the application levels and deficiencies of CE in the firms were identified (Khalfan, Anumba, Siemieniuch, Sinclair, 2001). Additionally, through the field studies conducted in the UK and Pakistan, using BEACON model, CE application levels of consultants, material suppliers, and contractors in the construction industry were examined (Khalfan, Anumba, Carillo, 2001a, 2001b, 2001c; Khalfan, 2007).

2.2.2. Team-based integrated product and process development

Since CE requires the integration of people, process and technology, it also includes significant organizational changes. As a first step in this direction, a multi-disciplinary and cross-functional "Integrated Design and Construction Group" an entity sourced from different levels and departments should be established. "Design Function Deployment" (DFD) and "Concurrent Life Cycle Design and Construction" (CLDC) systems found in the literature are integrated design and build systems to be used for concurrent engineering approach (Evbuomwan and Anumba 1998).

In CE implementations, an experienced and independent "Project Manager" as a director of "Integrated Design and Construction Group" should be assigned to organize, manage, and control during the design and construction process of the project. The project manager should act like a coordination and integration mechanism. This manager, as the project leader, should work to obtain the best performance out of the "Integrated Design and Construction Group" whilst not giving a hierarchical authority impression. This group should be established from architects, design and manufacturing engineers (technical department), purchasing, marketing, manufacturing, quality assurance, representatives of other functional groups, customers, and suppliers. The group should operate concurrently in product and process development activities and bring different perspectives and solutions to problems. In this regard, the group should be constituted of four teams:

i. personnel team should fulfill design, manufacturing, sales, and service support duties effectively;

ii. technology team should create strategies with respect to advances in technology and tools to be used for the design perspectives;

iii. logical team should define the tasks and the logical layout for the realization of these tasks;

iv. virtual team should use the tools and computer techniques to step up each of the tasks and connect them.

The group must bear full responsibility for new products from concept to production.

No new product development team alone cannot have all of the information necessary to complete the process, thus, all teams need to integrate the information and data about the process. These multi-disciplinary teams although acting together at the beginning of the workflow, must make later decisions about product, process, cost and quality control issues based on consensus. Also, by working all of the parties together on the identification of the troubles and difficulties in advance from the start, schedule delays and other problems arisen in the manufacturing and operations can be eliminated. In this way, the walls between departments also will be destroyed.

In this integrated design and construction process, the group should do the following works:

- Because architects take place in the center of design development process within the product development activities, architects need to be responsible for ensuring the coordination of the group. At this stage, the project manager establishes multi-disciplinary "Integrated Design and Construction Group" under the guidance of architect and customer. Then, the manager initiates a project briefing by the participation of all the members. Created teams, by working as a whole, develop the project information about the design and construction while using the information obtained earlier phases. In this respect, project manager tells the needs and requirements of the customer to the team members. At this stage, the customer is encouraged to actively participate in the process throughout the design development stage. An actively participating client plays an important role in terms of taking responsibility for initiating, directing and maintaining the momentum of a project. The project manager should essentially appoint the architect as the "director of design briefing" during the design development. Architects should provide ideas about how to fulfill the aesthetically and functionally the needs of the customer. Design engineers should propose ways to design and develop the necessary structural and service-oriented capacities of the facility. The construction engineers should select the production personnel and develop and plan about production strategies and programs. The main suppliers should advise about alternatives for material and equipment. The marketing experts organize the potential tenants or buyers. In this way, individuals within the team acquire new abilities and skills about themselves and the needs about team members by learning from each other. Thus, the project team will learn how to learn together.
- The project director throughout the construction process should assume an active role in the coordination to ensure a smooth progression of the project. At this stage, the design and design consultants must be connected to the main contractor thus the contractor should be accepting the risk by undertaking the responsibility. The main contractor should also be responsible for the selection of sub-contractors and suppliers that were the strategic alliances. A quantity surveyor must analyze the cost of the works to be committed. This quantity surveyor should also act as an adviser to the customer, project manager, and main contractor.

2.2.3. Multi-disciplinary teams and the organization's management

The companies, which adapt CE approach to their management systems, have to rethink their organizational structures, personnel policies, system infrastructures, product and process improvement approaches, and customer and supplier interactions. The success of implementation of CE is affected not only by the creation of multi-disciplinary and cross-functional teams and also by the company's managerial and organizational structure. At this stage, the companies should try to manage the boundary between integrated design and construction group and the rest of the organization. In this regard, the most appropriate management structure for concurrent engineering was mentioned as Total Quality Management (TQM) and for an organizational structure as the Matrix-Project Type organization (Sekerci 2008).

The existence of a well defined and documented quality management system determined within the framework of TQM philosophy is required for CE applications. However, the use and management of information technology that has the great potential to facilitate the effective application of CE methodology is important in terms of both organizational and technological infrastructure.

In the matrix structure revised in line with the concept of the CE, the project manager acts as a virtual assistant general manager of the company. The project manager distributes the tasks as required by the four-dimensional integrated design and construction group that was set by the project to the functional departments (Figure 1). In this way, the development of functional knowledge and expertise of the people positioned in these sections and also the easy transfer of these people between projects are accomplished. Members of the department can be appointed in all or part of the project, during the continuation of the project. However, these people still continue to remain as a part of the functional departments. The relationships established because of the project integrate these members and also make it easy the planning and control efforts. This process allows these people to increase their work and contributions by dedicating themselves to fulfill the objectives of the project.

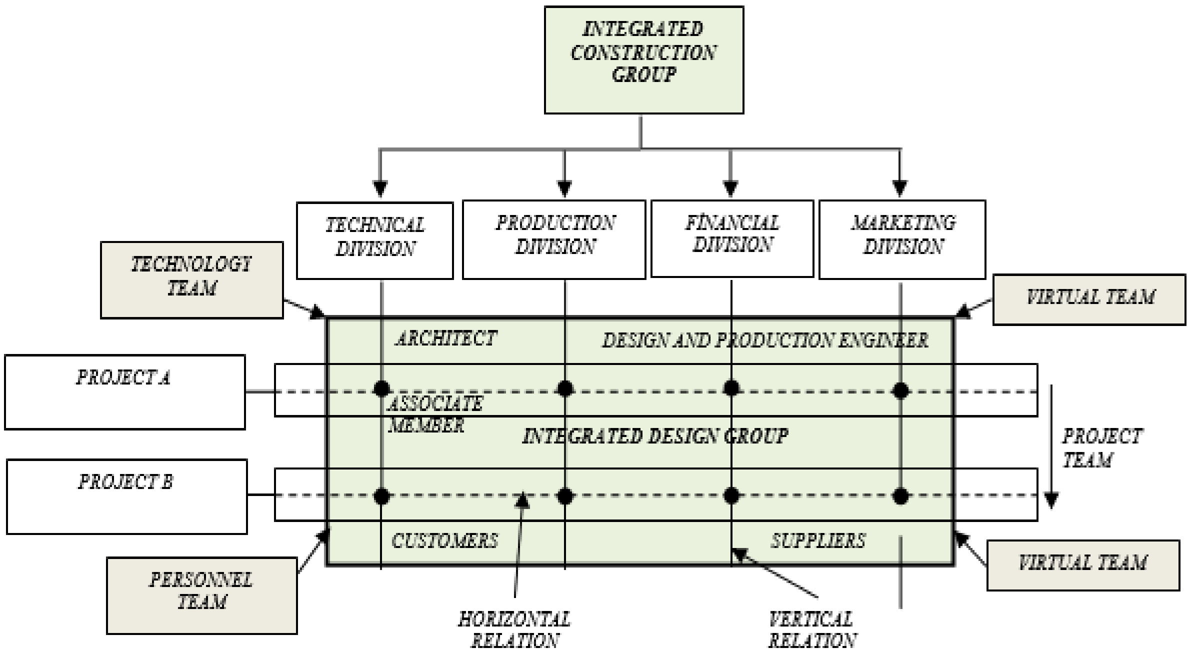

Figure 1. The matrix organizational structure revised according to Concurrent Engineering approach

2.2.4. Feedback used in the development of processes

As a last step for the successful implementation of concurrent engineering, a system to be used in product development process is created by writing down the experiences and lessons learned from previous projects. This approach helps to ensure institutionalization of practices toward the sustainability of CE in the organization.

3. Material and Methodology

In this study, the applicability of Concurrent Engineering concept in Turkish construction sector was investigated. The main purpose is whether there is any connection between the close participation of project participants and the compilation of project signifying the importance of concurrent engineering from the architects' opinion. There might be a relation between what happen at the beginning of a project and what is got at the end of a project. Can it be said that the attendance of project participants at the design stage has some kind of implications on the output of a project. For example, when an owner joins all the meetings, does it affect the success or a timely completion of a project? As another example, can a request for plan changes affect the project outcome as increased project time or over budget?

In this context, the perspectives of architects who assume the main role in implementing concept of CE have been identified through a survey. Accordingly, in the questionnaire, personal information about the respondents, information related to work life, and also knowledge about CE practices has been sought after. The questionnaires were delivered through the internet with the contribution of the branches in various cities' chamber of architects and then 97 responses were received. Detailed information about the survey is given through face to face or telephone interviews. Then, the answers to the questionnaires have been evaluated statistically and also cross checks are made.

4. Evaluation of Survey Results

As mentioned before that the concurrent engineering is about forming a team which has cross-functional properties. So, what is the real situation in industry? The respondents may not know or formally aware of the concurrent engineering concepts but still might have been employing the basics of concurrent engineering.

Table 1. Responses to some selected employed concurrent engineering concepts

Which of the following activities did you perform in your previous projects?	Average of "YES"	St. Dev. of "YES"
j. The design changes before manufacturing/construction were minimized?	%87	%34
k. Activities of various disciplines involved in the project were integrated?	%80	%40
f. To bear full responsibility of new products from conceptualizing to manufacturing, multi-disciplinary, cross-functional, and continuously-learning teams were created?	%53	%50

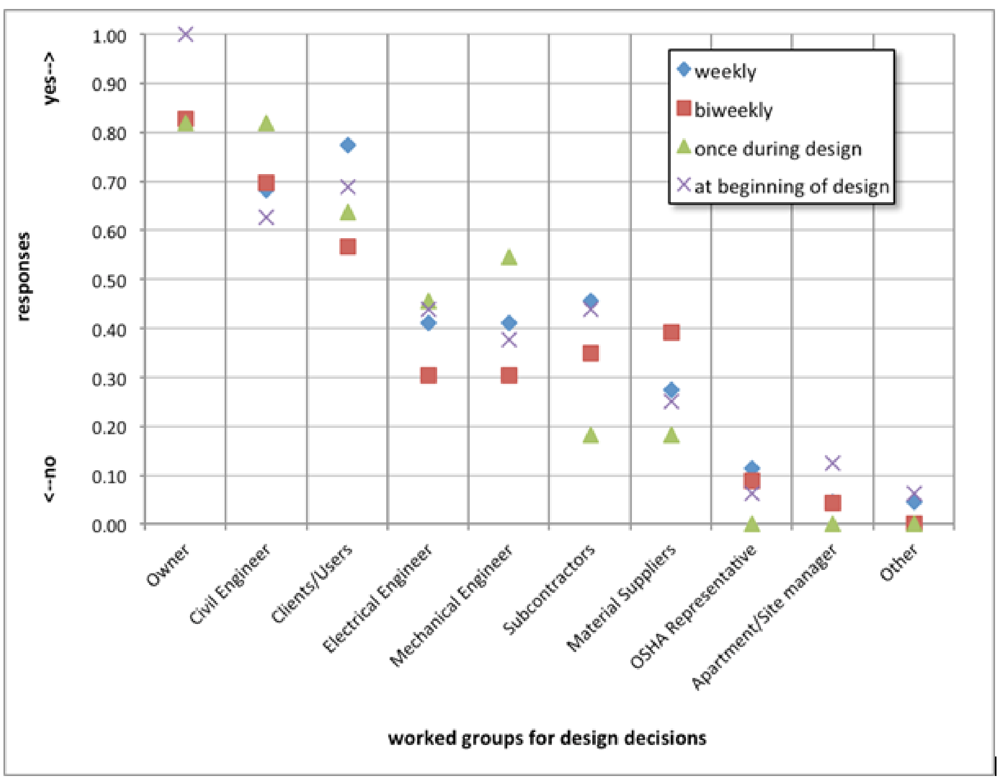

Figure 2. Worked groups in association with architects for design decisions.

The design changes were minimized according to 87% of respondents according to Table 1. Also the question of "have there been changes in project during construction without notification" (Question 8) was asked and 30% said "rarely"; 38% said "sometimes"; 14% said "very often"; and 18% said "none". These responses indicate that there has been a substantial amount of changes in the plans in different phases of the projects. These two findings are seemingly contradicting but tell us that changes occur nonetheless. Also the multi-disciplinary, cross functional teams created according to half of the respondents in Table 1. This is an important concept in concurrent engineering. The low response rate indicates that the integration of teams in their previous projects was weak.

Figure 2 shows the relation between "frequency of meetings with stakeholders during design phase" (Question 6) and "worked groups along with architects for design decisions" (Question 5). The "design" may not only be translated not as "design" but also as "conceptual development". The owner is the foremost participant in these meetings followed usually by civil engineer and client/user. The participants can be grouped into three: 1. owner-civil engineer-client/user; 2. electrical & mechanical engineers-contractors-material supplier; and 3-others. The third group (workplace safety specialist, apartment/site manager, and others) can be omitted from the following discussions since the weight of their opinions is below 10%. Owner is absolutely present at the beginning of the design and compared to other groups s/he almost always present in design phase meetings. Civil engineer joins the meetings at least once but not at the beginning of the design phase.

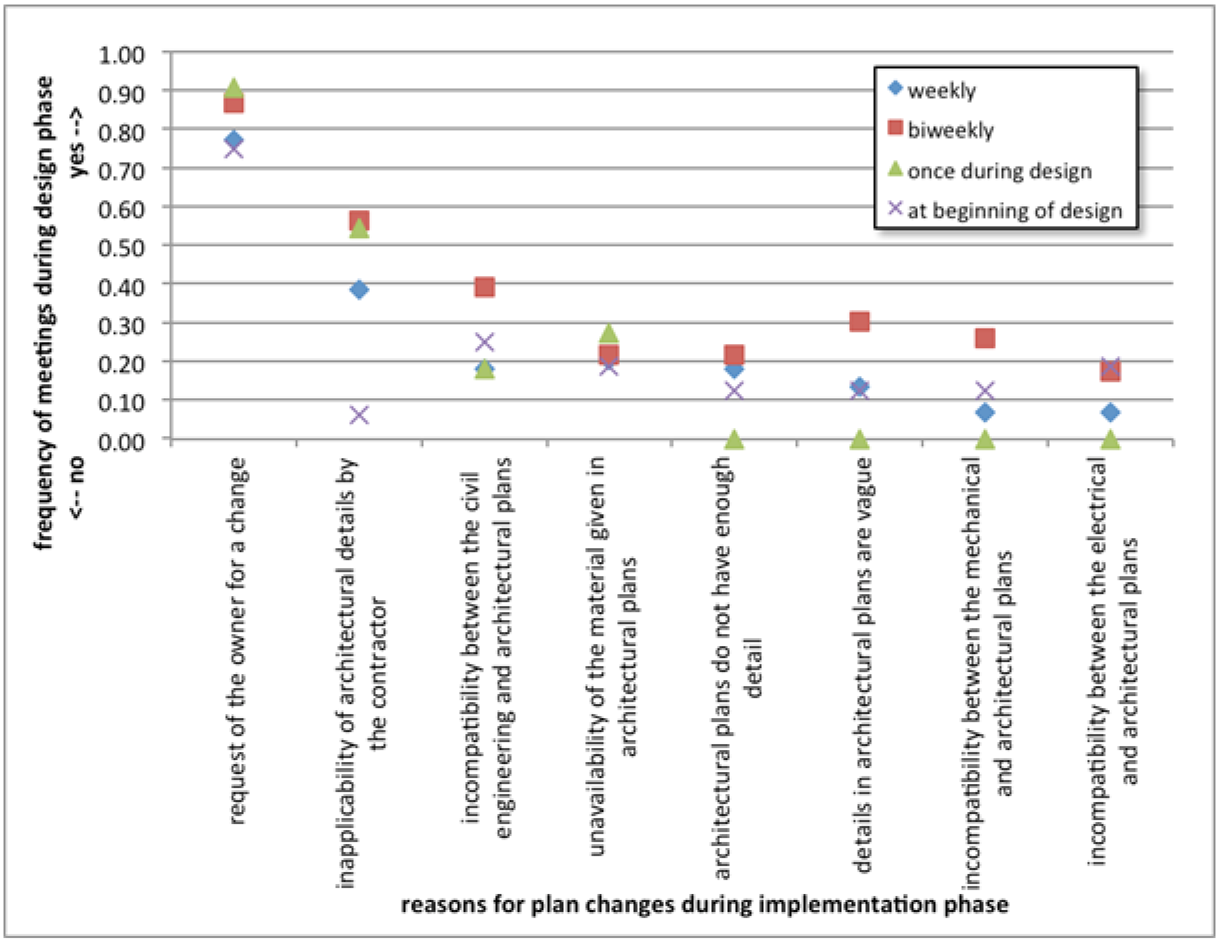

Figure 3. The relation between the frequency of meetings during design phase and reasons for plan changes during implementation phase.

Figure 3 shows the relation between the "number of meeting with stakeholders during design phase" (Question 6) and "reasons for plan changes during implementation phase" (Question 9). Since it is seen that the owner is almost always present in the meetings during design phase, the high number of design changes due to the request of the owner can be explained as either the owner requests are irrational or the owners are not informed sufficiently. Aside from the owner requests, let us look at the other reasons for plan changes. The inapplicability of architectural details by the contractor and incompatibility between civil engineering and architectural plans are other important reasons for plan changes during application phase. It is interesting that the frequency of meetings does not greatly affect the plan changes due to the unavailability of material given in architectural plans. This could have been avoided by having a person who is more knowledgeable about the materials whether this person from a supplier or from the contractor in meetings.

"Has there been a demand for changes in project during construction" (Question 7) was asked in the survey to architects. Figure 4 shows the relationship between "demand for changes during construction" (Question 7) and "reasons for plan changes during implementation phase" (Question 9).

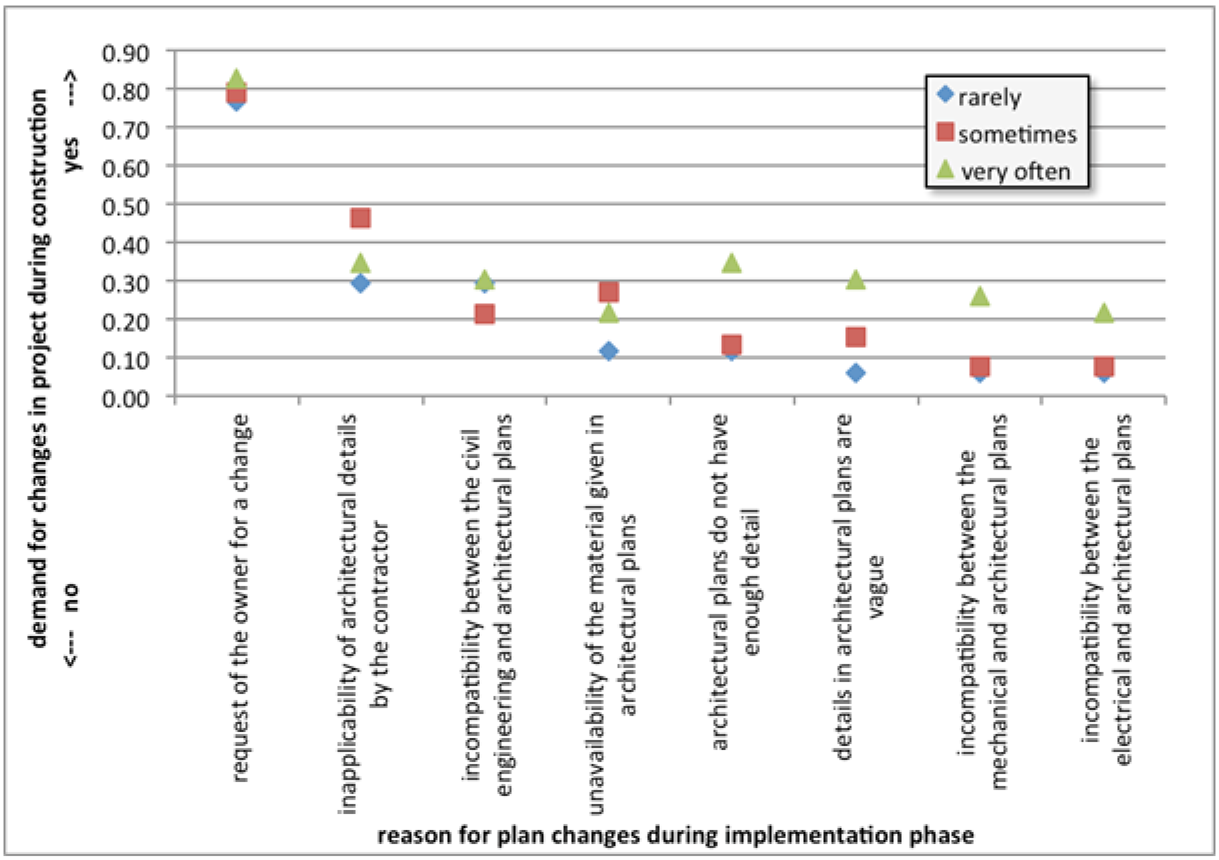

Figure 4. The relation between demand for changes and reasons for plan changes during construction.

According to Figure 4, demand for plan changes during construction due to owner request is again the most probable cause. Aside the demands of owner, demands for changes due to vagueness or not having enough details in architectural plans and incompatibilities between architectural and mechanical and electrical plans happen very often.

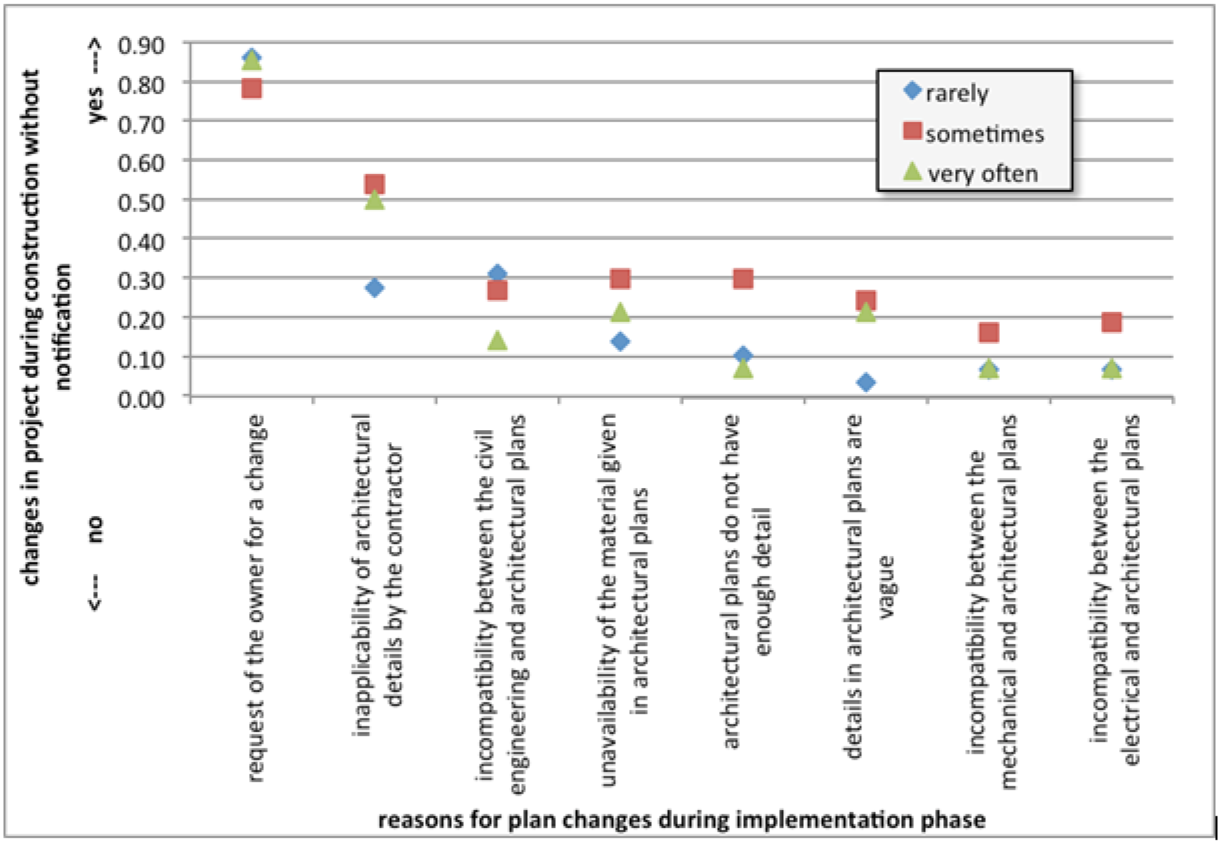

Figure 5. The relation between occurred changes without notification and reasons for plan changes during implementation phase.

Figure 5 shows us the relationship between "occurred changes during construction without notification to architect" (Question 8) versus "reasons for plan changes during implementation phase" (Question 9). Again putting aside the changes made due to owner's demands, let us compare this with Figure 4. The factor of inapplicability of architectural details by the contractor moved from less probable to more probable. The changes without notification increased for "rarely" and "sometimes" responses compared to Figure 4. The "very often" response for the factor of "architectural plans do not have enough detail" in Figure 4 changed to "sometimes" response in Figure 5. From these it can be said that the insufficiency in architectural plans is cleared after having the meetings. Also it is seen that the demand for changes due to the incompatibilities between the mechanical and electrical plans and architectural plans shifted from very often to sometimes frequency in Figure 5 which means its frequency is lessened. It can be concluded that the meetings held before the project starts really serve the purpose. Also the incompatibilities between architectural and civil engineering plans are met with "very often" response before project starts while the response becomes "sometimes" during project execution. There is no change in the responses related to unavailability of materials. After these discussions it can be said that having meetings helps to improve the engineering drawings.

No difference is observed related to the "material not found" factor in Figure 5. As a result, it can be said that all these meetings held provide further improvements in drawings/design of other engineering disciplines. Moreover, it can be said that the predictions of the contractor about what it would be encountered during the execution of the project is somewhat poor or indeed no one could have foreseen the possible situations during project execution. Also because of the fact that despite the contractor attending meetings if the material still cannot be found available during project execution, either the contractor should attend more meetings, or more knowledgeable person/s with materials should be present in meetings, or more work related information should be provided to the contractor.

In summary, it can be said that the business owners are not behaving rationally, there are requests for changes as his/her desires alter. Thus, although having meetings is effective, having so many meetings do not too much affect the arising problems related to owner. It has been seen that the contractor attend only a few meetings. Therefore, by ensuring greater involvement of the contractor, change requests, unannounced modifications and the inappropriate choice of materials can be reduced.

On the whole, the question is that whether all these change requests affect the project results or not. Let us evaluate two criteria as project outcomes or results. The persons are asked the probable changes in project outcomes if the concurrent engineering concepts were not applied. One choice is that if the project schedule is expected to increase and the other is that if the project cost is likely to go up. In Tables 2 and 3, these results are compared for change requests and changes that occurred, respectively. In Tables 2 and 3, the average values and the standard deviations (in parentheses) of responses are given.

Table 2. The relation between "demand for changes in project during implementation" and project output.

Has there been a demand for changes in project during implementation Rarely:1 Sometimes:2 Very often:3	**Disruptions caused by not implementing concurrent engineering** ***b: Increase in the project duration*** 1:most likely 5:least likely	**Disruptions caused by not implementing concurrent engineering** ***a: Increase in the project cost*** 1:most likely 5:least likely
1	2.88 (1.27)	2.59 (1.50)
2	2.38 (1.22)	2.75 (1.43)
3	2.30 (1.11)	3.04 (1.52)

Table 3. The relation between "occurred changes without notification in project during implementation" and project output.

8. Has there been changes in project during implementation without notification Rarely:1 Sometimes:2 Very often:3	**Disruptions caused by not implementing concurrent engineering** ***b: Increase in the project duration*** 1:most likely 5:least likely	**Disruptions caused by not implementing concurrent engineering** ***a: Increase in the project cost*** 1:most likely 5:least likely
1	2.62 (1.37)	2.62 (1.45)
2	2.38 (1.23)	2.97 (1.57)
3	2.21 (1.12)	2.93 (1.59)

It can be said that, too often and unannounced changes made in the drawings are likely to cause an increase at the project duration from Table 3. Likewise the presence of change requests which happens very often for design is causing the duration of the project to increase more likely from Table 2. In an interesting way, on the other hand, when change requests or occurred changes that take place very often then there is more likelihood for a slow increase in project costs. This result can be speculated as follows; if we consider that the change requests are usually done by the owner, then these requests may not cause a rise in costs although leading for delays in the project schedule. Perhaps such reason as requests for the different materials causes to investigate other options which could be more affordable, but meantime to an increase in time that is spent for the investigation. Also such cases as insufficient architectural details and delayed procurement of related materials of those details are the primary reasons (after which depending on owners) among requests for changes and for occurred changes. Again, perhaps market research for materials is causing a delay but results with finding more affordable alternative.

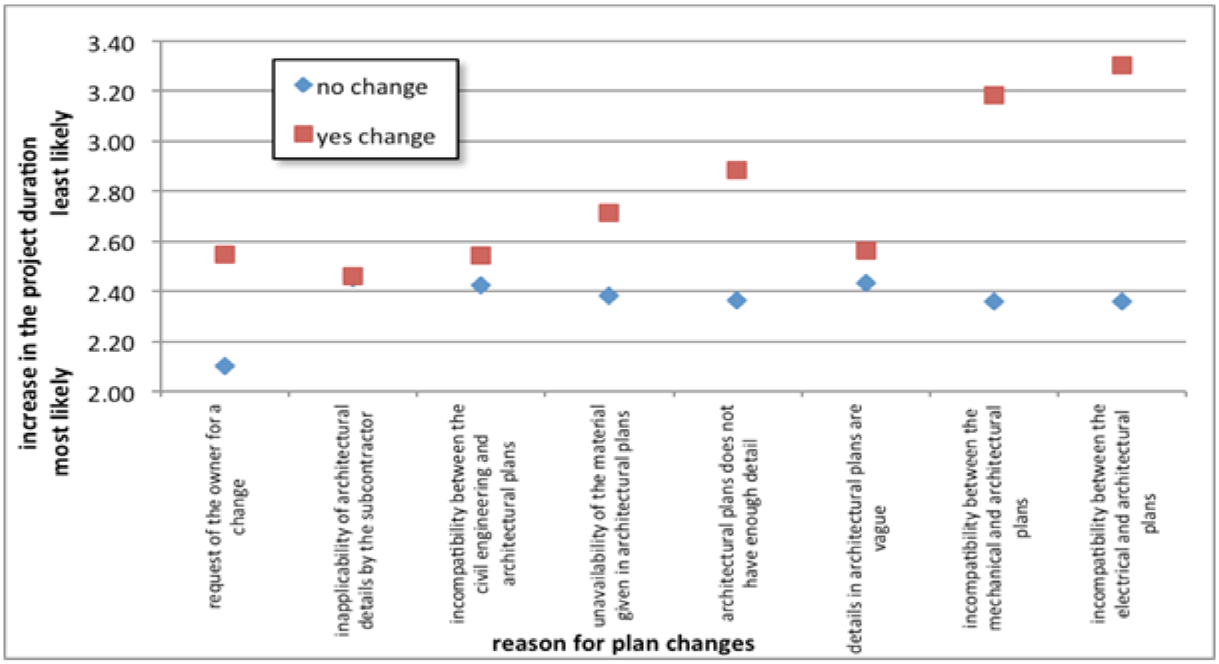

Figure 6. The relation between reason for plan changes and likelihood of an increase in project duration.

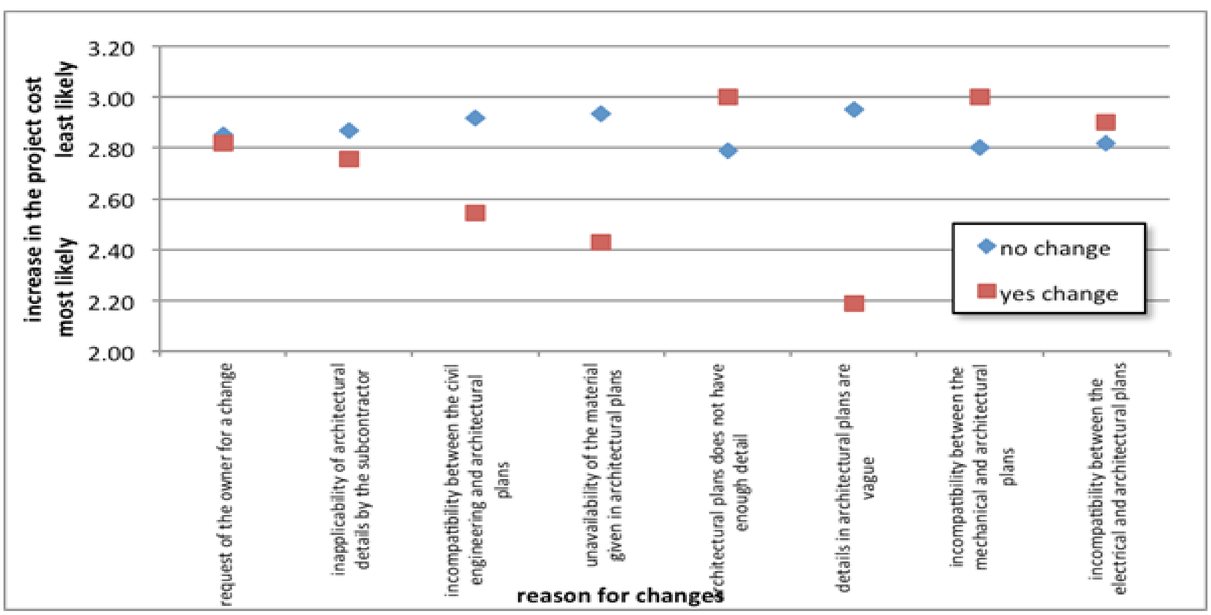

Figure 7. The relation between reason for plan changes and likelihood of an increase in project cost.

It is seen from Figures 6 and 7 that some reasons for changes than others can become important in project outcomes. For example, the changes due to incompatibilities between architectural and electrical or mechanical projects are probably causing an increase in the project duration meanwhile not causing too much of a project cost increase. On the other hand, the ambiguities in the architectural plan and the lack of materials cause it possible to increase the project cost, although not very much affective on project duration.

5. Conclusions

Concurrent engineering concepts can also be applied in construction industry. An appropriate application of the concepts should provide an improvement in the implementation of the construction project. Through meetings to be held in the project, design drawings and plans will be more likely to have fewer problems. The improvements can be obtained both during the project and at the completion of the project. In this study, what concurrent engineering is and how it should be implemented is described. In a survey, 97 interviews with architects are conducted. The relationship between concurrent engineering concepts and project features and results are examined. Results show that although the concepts are not applied in formal and deliberate ways they have been useful. For example, the change requests occurring at different times were shown to be caused particularly by owner. The relationship between frequency of the meetings held and the change requests or occurred plan changes showed that the improvements might be possible. This study also indicated that the creation of cross- functional team an important concept of concurrent engineering is important. As an improvement, contribution of other engineering disciplines, contractor and suppliers as the team members toward the reduction of the changes in the project can be achieved. Furthermore, for in time and within budget completion the project as the outputs of the Project, the concepts of concurrent engineering have been shown to be helpful.

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